OCCIPITO-CERVICAL FUSION
An Operative Technique and its Indications

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The problem of the unstable atlanto-axial joint and its treatment usually stimulates lively discussion by orthopaedic surgeons and rheumatologists. There is not only difference of opinion about the indications for stabilisation, but a deep division amongst surgeons about the necessity for inclusion of the occiput in the fusion. Theoretically there seems little justification for it if the displacement is between the atlas and axis (C.1–2). Yet many surgeons, the authors included, are convinced that fusion from the occiput to the axis is not only desirable but also, because of the small range of movement between the occiput and atlas, that it adds little to the restriction of movement.

The purpose of this paper is not so much to persuade our colleagues to give up the practice of fusing C.1–2 alone, but rather to describe and discuss the indications for a simple method of occipito-cervical fusion for which we claim no originality but which seems to work in practice and has been used at The Middlesex Hospital for many years. Perry and Nickel (1959) described a similar procedure as part of fusion of the whole neck for instability after severe poliomyelitis. The method avoids the need for any form of internal fixation, for example by lag screw (Cregan 1966) or wires, and for neurosurgical assistance with the fusion as advised by Hamblen (1967). However, combined operations with neurosurgeons may still be necessary when decompression of the medulla is indicated.

INDICATIONS

The operation to be described has as its objective the stabilisation of an unstable atlanto-axial joint. We believe that it is a safe, simple and above all reliable method of achieving this aim, but we fully recognise that a successful fusion between the atlas and axis alone would achieve the same goal. Our reasons for preferring to include the occiput in the fusion will be discussed later. The indications for occipito-atlanto-axial fusion, as for atlanto-axial fusion, are therefore instability of the latter joint; but this is not all, because, certainly in rheumatoid arthritis, such instability is quite common and obviously not all patients require fusion. Indeed Sharp and Purser (1961) reported an incidence of instability of no less than 6 per cent in patients with clinical evidence of rheumatoid arthritis and 19 per cent among those who were admitted to hospital because of the arthritis.

Clearly, any patient with obvious instability associated with abnormal neurological signs in the limbs requires fusion. Likewise it seems reasonable to advise early fusion in patients with rheumatoid arthritis when the subluxation is either considerable, is associated with pain unrelieved by a collar, or is progressive. Excessive mobility of the atlanto-axial joint may also cause intermittent obstruction of the vertebral arteries (Ford 1952), and symptoms of basilar artery ischaemia in such patients are a further indication for fusion (Webb, Hickman and Brew 1968). The necessity for further surgical operations should also weigh in favour of fusion if there is doubt, because there is a risk of further backward displacement of an unstable dens during or immediately after general anaesthesia.

At the present time the main cause of atlanto-axial instability seen by the surgeon is rheumatoid arthritis. Other less common causes, which if gross or associated with neurological signs must be considered to indicate stabilisation, include congenital deformities (Hamblen 1967), congenitally separate dens (Wollin 1963), ununited fractures of the dens (Owen-Smith
1968), and other types of inflammatory polyarthritis—particularly if treated with large doses of corticosteroids (Case 2)—including ankylosing spondylitis (Meijers, Voss and Francois 1968). Spontaneous atlanto-axial subluxation (Watson Jones 1932) can usually be managed without operation (Werne 1957).

**OPERATIVE TECHNIQUE**

The operation is performed under endotracheal anaesthesia, special care being taken by the anaesthetist to avoid further damage during intubation. Before the operation starts, skull calipers are inserted and the patient is placed prone with the head held firmly in a head-rest with continuous traction to hold the atlanto-axial joint firmly in a position as nearly reduced as possible. Traction, apart from its usual stabilising effect, tends to hold the dens forward by stretching the tectorial membrane which is attached above and below it.

The operation is performed through a midline incision. The laminae and spinous processes of the axis and the central part of the arch of the atlas are cleared of soft tissues in the usual way. There is no need to expose more than about three centimetres of the arch of the atlas, thus avoiding any possibility of damage to the vertebral arteries, which are not seen. Muscles are detached from the occiput with a periosteal elevator from the margin of the foramen magnum to a point near the superior nuchal line, usually over an area of about twelve square centimetres (Fig. 1).

The spinous process of the axis and both laminae are prepared to receive the graft by decortication with nibbling forceps. At this stage one can see the tenuous nature of the arch of the atlas: sometimes it is little larger than the wishbone of a chicken and occasionally, particularly in congenital separation of the dens, even deficient centrally (Wollin 1963). It is not then difficult to understand why attempts to graft the atlas to the axis alone so often fail, particularly as the subluxation is horizontal whereas the graft, with such scant attachment above, lies vertically. Decortication of the prepared area of the occiput is neither practicable nor necessary. All that is needed is to roughen the surface and raise fine slivers of superficial cortical bone with a sharp osteotome. The procedure is safe, and avoids thermal damage to bone cells which must occur if a dental burr or similar high speed instrument is used.
The operation is completed by simply packing this bed of bone from occiput to axis with a mass of finely chipped cancellous bone removed from the outer table of the ilium (Fig. 2). The wound is closed and the patient turned on to a Stryker or similar turning bed with continuous skull traction of 3·5-4·5 kilograms. No other immobilisation is necessary.

Before the operation a cast is taken for a high plastic collar. This is applied six weeks after operation when the skull calipers are removed and the patient is allowed up. This collar is worn whenever the patient is out of bed until radiographs show firm consolidation of the graft, which is usually about six weeks later.

MATERIAL

We have operated upon nine patients by this technique: five had rheumatoid arthritis (one also with fracture of the dens), one had inflammatory polyarthritis associated with ulcerative colitis, one had congenital separation of the dens and two had fractures. Solid fusion was obtained in all, although one patient (Case 4), in whom the operation was performed after posterior decompression with removal of the lamina of the atlas, developed a pseudarthrosis which necessitated a second graft.

ILLUSTRATIVE CASE REPORTS

Case 1—A woman aged fifty-five with moderately severe rheumatoid arthritis first attended hospital nine years after its onset. Six months after her first visit she complained of an ache in the neck; four months later she developed paraesthesiae in both hands and complained that her hands were clumsy and that she could not hold things.

Examination revealed a glove type of reduced sensation of both hands and weakness of both arms, mainly the right. Joint position sense of the fingers was reduced in the left hand and absent in the right, where vibration sense was also absent. The abdominal reflexes were absent, there was a little spasticity of the left leg and both plantar responses were extensor. Radiographs showed upward and backward displacement of an eroded dens (Fig. 3). Occipito-cervical fusion was performed one month after the onset of paraesthesiae in the hands.

Since fusion the patient has lost all neck pain and there has been a marked improvement in the subjective sensory symptoms in her hands. Neurological signs, however, remain unchanged one year later.

Comment—Posterior fusion between the atlas and axis alone in this patient would clearly have been very difficult because of the upward displacement of the atlas and the proximity of its lamina to the occiput. The radiograph also illustrates a possible danger in the insertion of a loop of wire between the posterior arch of the atlas and the axis, the procedure usually advocated (Grogono 1954) for such fusion. Tightening of such a wire would tend not only to reduce the backward subluxation of the dens for which it is recommended, but also to increase its upward displacement with possibly dire consequences. Fusion from the occiput to the axis alone could prevent further upward movement of the atlas due to rheumatoid erosion of the articular surfaces.
Case 2—A woman of twenty-five suffering from ulcerative colitis and treated with corticosteroids for eight years developed acute polyarthritis with a stiff neck ten months before her admission for operation. The neck had remained painful and rather stiff, and flexion-extension radiographs showed subluxation of the atlanto-axial joint (Fig. 4). The indications for occipito-cervical fusion (Fig. 5) were pain, the radiographic appearance and the likely need for further surgery which did in fact become necessary one year later when total colectomy was performed. The patient states that she is not inconvenienced by the limitation of neck movement (Fig. 6).

Case 3—A woman aged seventy complained of numbness of the right hand for three years and of the left for six months. During the past three months she had also noticed weakness of the right hand and of both legs, and unsteadiness of gait. Examination revealed a mild tetraparesis and cerebellar signs of basilar artery insufficiency.

After fusion from the occiput to the axis there was slow improvement in the neurological signs and even more marked subjective improvement in both motor and sensory symptoms of both conditions.
Case 4—A thirty-nine-year-old taxi driver had suffered a head injury in childhood but remained free from symptoms until he developed paraesthesiae in the right hand and right side of the head soon after falling down stairs four years before his first attendance. He had recently developed increasing weakness of the right arm and leg. Examination revealed mild tetraparesis.

Radiographs showed marked subluxation of the atlanto-axial joint with wide separation of the dens (Fig. 7).

At a combined operation with a neurosurgical colleague, Mr J. Andrew, posterior decompression was performed by removing the central part of the arch of the atlas. The dura
was opened. The exposed area of dura was covered with gelatin foam sponge and posterior fusion was performed in the usual way.

Progress—The neurological signs increased when traction was removed at six weeks, and radiographs showed pseudarthrosis of the graft (Fig. 8). Myelography confirmed that posterior decompression was inadequate (Fig. 9). At a second operation, this time with the additional assistance of an ear, nose and throat surgeon, Mr R. Williams, the spinal cord was decompressed anteriorly through the mouth and posterior pharyngeal wall. Part of the protruding part of the dens was cut away, allowing the cord to move forwards. The orthopaedic surgeon’s part in this procedure was to insert a graft into the prepared bed between the bodies of the atlas and axis. This graft was extruded into the mouth a few weeks later (Fig. 10), but in spite of this the wound healed without other complication. Later the pseudarthrosis of the posterior graft was regrafted and solid posterior fusion was obtained after the usual post-operative routine had been followed. The patient’s neurological deficit improved; he remains independent but walks with a spastic gait, and there is marked weakness of the right hand.

Case 5—A boy of fifteen was first seen two months after an injury to his neck caused when another boy jumped on to him in a swimming pool. Radiographs revealed a fracture of the dens. The fracture remained ununited in spite of six weeks’ traction followed by three months in a Minerva plaster (Fig. 11). There were no abnormal neurological signs. After successful occipito-cervical fusion the fracture of the dens also united (Fig. 12). The range of neck movements eighteen months after fusion is shown in Figure 13.

DISCUSSION

We are chiefly concerned here with three aspects of the surgical treatment of atlanto-axial subluxation: the indications; the extent of fusion and whether or not the occiput should be included; and the technique to be followed.

Indications—Some consideration has already been devoted to the indications for surgical fusion, and most surgeons have little difficulty in making a decision in favour of operation in those patients presenting with what one might regard as the absolute indications for fusion, namely, evidence of cord compression, unrelieved pain, or progressive severe subluxation. The difficulty arises in patients, usually with rheumatoid arthritis, without severe symptoms and with a moderate degree of subluxation only. We have no knowledge of how many of these patients progress to severe deformity, or indeed how many may die suddenly from massive cord damage such as that described by Pratt-Thomas and Berger (1947), Davis and Markley (1951) and by Martel and Abell (1963), or from vertebral artery thrombosis as reported by Webb and his colleagues (1968). Treatment with a collar can only be of limited value, because even in a Minerva plaster subluxation has been shown to progress (Blockey and Purser 1956; Sharp and Purser 1961). A collar, however, should protect the patient from sudden extremes of movement such as might occur in a fall or motor accident. Such relatively common accidents must always remain a frightening hazard for any patient with atlanto-axial instability.

We believe that many more patients die from atlanto-axial dislocation than has hitherto been recognised. Furthermore, it may well be that in many patients early symptoms of cord compression, often no more than weakness and paraesthesiae, may be confused with other more common benign symptoms in the patient suffering from severe rheumatoid arthritis. Thus in one of our patients (Case 3) paraesthesiae of the fingers was at first thought to be due to carpal tunnel compression of the median nerve. Likewise, weakness could be wrongly attributed to painful stiffness and deformity of joints.

In our view, therefore, much more attention should be paid to the possibility of subluxation of the atlanto-axial joint in patients with rheumatoid arthritis, and until it can be shown that a conservative policy is safe the surgeon in doubt should err more on the side of fusion than of inactivity.
Extent of fusion—Many surgeons prefer posterior fusion between the atlas and axis alone (Grogono 1954, Lipscomb 1957, Rogers 1957, Wollin 1963, Hunter 1968), but Forsyth, Alexander, Davis and Underdal (1959), because of redislocation in two of their patients, advocated the inclusion of the third cervical vertebra. Alternatively, transoral interbody fusion between the atlas and axis may be performed but, as in Case 4, this also may fail. Although in theory fusion between the atlas and axis alone should be ideal in patients with

subluxation at this level, there is a high incidence of failure in the reported series (Lipscomb 1957, Forsyth et al. 1959, Owen-Smith 1968). Grogono’s two successes were in children aged four and ten, and Hunter’s only patient was eighteen. We therefore agree with Owen-Smith that inclusion of the occiput is preferable. Indeed, when instability at C.1–2 is accompanied by upward displacement of the dens from rheumatoid arthritis affecting the atlanto-axial joint, fusion from the occiput downwards is essential. Interlaminar wiring and atlanto-axial fusion under such circumstances might well be dangerous.
Against all this there are two arguments in favour of localised atlanto-axial fusion. First, that by the tightening of interlaminar wires posterior displacement of the dens can be reduced. And second, that immobilisation of the occipito-atlantal joint imparts a further and very considerable addition to the limitation of movement produced by atlanto-axial fusion alone. Both arguments are in our view invalid, for in the first place total reduction of the dens is unnecessary: partial reduction with stability is all that is required, although often complete reduction is achieved by occipito-cervical fusion followed by skull traction for six weeks. Secondly, the additional limitation of movement from inclusion of the occipito-atlantal joint is much less than is generally realised. We certainly cannot agree with Hunter (1968) who considered that the advantage of limiting fusion to the atlanto-axial joint is that “an almost normal range of movement is preserved.” No other author has to our knowledge made such a claim.

**Limitation of movement**—We are concerned with flexion and extension and lateral bending only, because there is virtually no rotation at the occipito-atlantal joint. Werne (1957) showed radiographically in normal subjects that the average range of flexion-extension at the occipito-atlantal joint is no more than 13 degrees, and rather surprisingly that it does not vary with age. Lateral bending at this joint is found to be only 8 degrees. Thus, with a total range of flexion-extension in the cervical spine of 140 degrees (Kottke and Mundal 1959) and of lateral bending of 90 degrees, the contribution from the occipito-atlantal joint must be of relative insignificance. However, with the atlanto-axial joint having an average range of 47 degrees of rotation and 10 degrees of flexion-extension (Werne 1957) it is fusion at this level that accounts for the significant loss of movement after either atlanto-axial fusion or occipito-atlanto-axial fusion. The essential point is that the disability is about the same in either case. Indeed, even if one does not accept Werne’s low figure of 13 degrees for the flexion-extension range of the occipito-atlantal joint, preferring instead Fielding’s (1957) figure of 35 degrees, even this is low compared with the total range of neck movement. Perhaps even more important, our patients have complained only of lack of rotation of the head and this could not have been affected by inclusion of the occiput in the fusion.

**Technique of fusion**—Simplicity, safety and reliability are the only advantages that we claim for this method of fusion. The technique is not original, for Perry and Nickel (1959) and others have used the same or minor variants of it before. Nevertheless it does not seem to be so well known as other more complicated methods, some even necessitating a combined operation with a neurosurgeon (Hamblen 1967). Perhaps because of this, many surgeons have come to believe that occipito-cervical fusion is difficult to achieve. This may well be so when an extensive posterior decompression has been performed, or in the presence of severe congenital abnormalities such as those in half the patients described by Hamblen.

Most of the patients seen today in whom fusion is indicated do not require decompression; they are usually suffering from an early and relatively mild neurological deficit due to the effects of rheumatoid arthritis on the atlanto-axial joint. It is for these patients as well as those with ununited fractures that this simple method is ideal. With such a method advancing age is not a contra-indication.

**SUMMARY**

1. A relatively simple method of occipito-cervical fusion using autogenous bone chips without internal fixation is described.
2. In patients with atlanto-axial subluxation posterior fusion from the occiput to the axis rather than from the atlas to the axis is more reliable and is preferred. Inclusion of the occiput adds no more than a few degrees to the restriction of movement that follows C.1-2 fusion.
3. The indications for occipito-cervical fusion are discussed, particularly in relation to C.1-2 instability in rheumatoid arthritis.
REFERENCES


